STOP-ROTOR ROTARY WING AIRCRAFT

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a non-provisional of and claims priority under 35 U.S.C. Section 119(e) to U.S. Provisional Application 61/094,794, filed Sep. 5, 2008. The entire content of this provisional application is hereby incorporated by reference in its entirety.

BACKGROUND

1. Field of the Invention

The invention relates generally to unmanned aircraft designs, and, more particularly, to aircraft designs that combine the features of helicopter and fixed wing aircraft.

2. Description of the Related Art

Some unmanned aircraft designs attempt to combine the vertical takeoff and landing (VTOL) and hover capabilities of a helicopter and the increased speed and range capabilities of fixed wing airplanes. Stop rotor "nose sitter" configurations, so named because the aircraft takes off and lands from a nose-down orientation, may offer good hover efficiency and aerodynamic design but can require complex mechanical systems. These designs can also suffer a significant loss in altitude during transition from helicopter to airplane mode, and involve uneven weight distributions, rendering the aircraft "top heavy" and unwieldy during takeoff and landing. Further, the counter-rotating fuselage and tail of some "nose sitter" designs are less practical than aircraft designs with a conventional fuselage orientation and tail rotor. "Tilt rotor" configurations with tiltable rotating propellers also involve mechanically complex systems and decreased hover efficiency due to higher disk loading. "Tail-sitter" designs, so named because the aircraft takes off and lands from a tail-down orientation, are associated with poor hover efficiency due to high disk loading and an awkward 90 degree attitude change between hover and forward flight modes.

The compound helicopter has a rotor system driven by an engine for takeoff, hovering, and landing and an additional propulsion system and supplemental wing independent of the rotor system. At higher speeds, the rotor system does not drive the aircraft and is substantially unloaded by the lift of the wing. Compound designs also have disadvantages: they are heavy due to additional systems and can suffer a significant download penalty when hovering due to the presence of the wing in the rotor downwash. The canard rotor wing configuration contemplates a rotor that stops in flight and acts as a fixed wing, but it too suffers drawbacks. The shape of its airfoil compromises between forward and reverse airflow directions, leading to reduced performance in both flight modes. Similarly, tilt duct designs, whose propellers are shrouded in ducts and rotate between flight modes, suffer from poor hover efficiency and high drag in forward flight mode. Thus, combining a helicopter's vertical takeoff and landing capability and efficient hover with a fixed wing aircraft's high speed and long range into one aircraft design while reducing or eliminating performance tradeoffs remains a significant aspect in aeronautical engineering.

SUMMARY OF THE INVENTION

The devices of the present invention have several features, no single one of which is solely responsible for its desirable attributes. Without limiting the scope of this invention as expressed by the claims which follow, its more prominent features will now be discussed briefly. After considering this discussion, and particularly after reading the section entitled "Detailed Description of the Preferred Embodiments," one will understand how the features of this invention provide several advantages over current aircraft designs.

One embodiment is an aircraft capable of helicopter and fixed wing flight modes. The aircraft includes a plurality of wings, each wing having a spar and a flap movable with respect to the spar; a flap actuator configured to move the flap; and a center section rotatably coupled to each spar and including at least one spar actuator. The spar actuator is configured to rotate at least one of the plurality of wings about a rotational axis of the spar when the aircraft transitions between helicopter and fixed wing flight modes.

Another embodiment is method for transitioning an aircraft between flight modes. The method includes changing the motion of a center section of the aircraft relative to a fuselage of the aircraft from a first flight mode to a second flight mode, where the direction of relative airflow over one of a plurality of wings reverses when the aircraft transitions between modes. The method also includes rotating the one of a plurality of wings such that a leading edge of the wing faces into the new direction of relative airflow.

Still another embodiment is an aircraft including means for changing the motion of a center section of the aircraft relative to a fuselage of the aircraft from a first flight mode to a second flight mode, where the direction of relative airflow over one of a plurality of wings reverses when the aircraft transitions between modes. The aircraft also includes means for rotating the one of a plurality of wings such that a leading edge of the wing faces into the new direction of relative airflow.

Further aspects, features and advantages of the present invention will become apparent from the detailed description of the preferred embodiment that follows.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features, aspects, and advantages of the present invention will now be described in connection with a preferred embodiment of the present invention, in reference to the accompanying drawings. The illustrated embodiments, however, are merely examples and are not intended to limit the invention.

FIG. **1** is a perspective view of an aircraft according to a preferred embodiment of the present invention that converts between helicopter and fixed wing flight modes, shown in helicopter flight mode;

FIG. **2** is a perspective view of a blade/wing system from the aircraft of FIG. **1**, shown in fixed wing flight mode with its outer skin removed;

FIG. **3** is an enlarged partial perspective view of the servo control system and the center section of the blade/wing system of FIG. **2**;

FIG. **4** is a cross-sectional, perspective view through the center section taken along line **4-4** of FIG. **3**;

FIG. **5** is a cross-sectional view through the blade/wings, the strap pack, and the center section of the blade/wing system taken along line **5-5** of FIG. **2** but shown in helicopter flight mode;

FIG. **6** is an enlarged view of the strap pack of FIG. **5**;

FIGS. **7**A, **7**B, **7**C, and **7**D are perspective views of the aircraft of FIG. **1**, shown in blade/wing-stopped helicopter mode, hover/low speed helicopter mode, fixed wing mode, and high speed helicopter mode, respectively.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The following detailed description is directed to certain specific embodiments of the invention. However, the inven-